

Consultation Section

Edited by Dennis D. Shepard, MD, FACS

Q • How do you calculate intraocular lens (IOL) power after radial keratotomy (RK)?

A • There are three methods, other than manual or automated keratometers, for determining the proper K-readings for IOL calculations in patients who have had keratorefractive surgery prior to the development of a cataract: (1) calculated method, (2) contact lens method and (3) refractive power measurements from corneal topography.¹

Calculated method. Subtract the change in refraction from the keratorefractive procedure, vertexed to the cornea, from the average value of the k-readings prior to the procedure. For example, a patient with a -4.00 diopter refraction and k-readings of 44.00 diopters prior to RK, who became plano 2 to 3 months after the surgery, would have a "calculated K" of 40.00 diopters. Refractions over 4 diopters must be vertexed to the cornea and care must be taken not to take the refraction too soon after surgery, before the cornea has stabilized and not too long after surgery when some of the refractive changes may be due to the cataract. This method is usually very accurate, but requires k-readings and the change in refraction from the keratorefractive procedure which are not always available.

Contact lens method. This method requires placing a rigid contact lens on the patient with a known base curve and plano refractive power and deter-

mining the change in the spheroequivalent refraction with and without the contact lens. If the base curve of the plano contact lens is equal to the average power of the cornea there will be no change in the spheroequivalent of the refraction. If the patient were one diopter more myopic with the contact lens than without, the lens is 1 diopter stronger than the cornea. For example, if a patient's spheroequivalent refraction were -2.00 diopters with no contact lens, and became -3.99 with a contact lens with a base curve of 40.00 diopters and plano power, the cornea must be one diopter weaker than the contact lens, or 39.00 diopters. Any refractions greater than 4 diopters must be vertexed back to the corneal plane to avoid error due to vertex distances. This method works very well provided the vision is adequate to determine a reliable refraction (no worse than 20/80), and the contact lens does not cause excessive tearing causing extreme variability in the refraction with the contact.

Central power calculation from corneal topography. Within 1 year most of the corneal topography manufacturers will have software that will calculate the effective spheroequivalent power of the central zone of an irregular cornea. It is already available from some manufacturers. All of the corneal topography instruments measure thousands of points

D is the corneal power). If the refraction results instead in a -1.00 D refractive error (SE), the additional 0.50 D of myopia (-1.00-[-0.50]= -0.50 D) is due to the fact that the contact lens is 0.50 D stronger than the cornea and this difference must be *subtracted from* the base curve of the contact lens to arrive at the corneal power (e.g., if the base curve was 40.50 D, then the corneal power is 40.50-0.50= 40.00 D). Likewise, if the result is a +1.50 D refractive error (SE), this 2.00 D of hyperopic change (+1.50 - [-0.50] = +2.00 D) is due to the fact that the contact lens base curve is 2.00 D weaker than the corneal power and you must add the 2.00 D to the base curve of the contact lens (e.g., if the base curve was 40.50 D, then the corneal power is 40.50 + 2.00= 42.50 D). The problem with this method is that not all ophthalmologists have plano contact lenses readily available, but more importantly, it may be difficult to impossible to obtain an accurate refraction from the patient because of the cataract.

4. Corneal *topography* units may be capable of measuring the corneal curvature more accurately in eyes with refractive surgery than an office keratometer because they take the readings in a smaller optical zone and measure the real visual cornea in the RK patient. True accuracy of this postulate has not yet been proven. Holladay has developed, in cooperation with EyeSys, software to allow specific K reading measurements for IOL power calculation. This would be extremely useful for the RK eye if this proves to be accurate.

Finally, Koch⁵ discovered that modern theoretic formulas were far superior to regression formulas when evaluating IOL power for RK eyes. Therefore the first thing to do to improve accuracy is to refrain from using a regression formula (e.g., SRK, SRK II), to calculate the IOL power for these eyes. Choose a modern third generation theoretic formula such as the Holladay, Hoffer Q, or SRK/T. Personalization of these formulas improves their accuracy. My recent study⁶ of 450 eyes using one style of IOL by one surgeon revealed the greater accuracy using a combination of the above three formulas based on the axial length of the eye (Hoffer Programs). This system calculates powers for all three formulas and

recommends the Hoffer Q formula for eyes shorter than 22.00 mm (8%), the Holladay for eyes between 24.5-26.0 mm (15%), the SRK/T for eyes greater than 26.0 mm (5%) and an average of the three formulas for the normal range of 22.0 - 24.5 mm (72%). This system is available on a Casio FX-8500G handheld calculator with optional printer module which works with any office printer (or laserjet) or IBM disk for use with DOS or Windows.

Summary: When calculating an IOL power for a radial keratotomy eye, use a theoretic formula with personalization and obtain the corneal power by refractive history, contact lens method or corneal topography and be prepared for early post-operative temporary hyperopia (Fig 1). Explaining the inaccuracy of IOL calculation in these situations with the patient in advance will be beneficial to both the patient and the surgeon.

Kenneth J. Hoffer, MD
Santa Monica, CA

57 yo FEMALE: RK DONE OU 10 YRS AGO	
IOL Calculation for Right Eye	
Pre-RK: -6.25 - 1.00 x 90°	K: 44.50/45.50
(-6.75)	[45.00]
Post RK: +0.50 -0.50 x 40°	K: 40.50/41.00
(+0.25)	[40.75]
40 D Plano CL Overrefraction	-1.50 sph
Topography K: 38.50/39.00	[38.75]
CALCULATION METHODS	
1) Keratometer (B&L)	40.75
2) Clinical History	
- 6.75 + [1-0.012(-6.75)] = -6.25	
+0.25 + [1-0.012(+0.25)] = +0.25	
RK Change in Myopia	6.50
K = Pre-K - ΔRx = 45.00 - 6.50 =	38.50
3) Contact Lens	
K = CL - [Base_{RX} - CL_{RX}]	
= 40 - [+0.25 - (-1.50)]	
= 40 - [+1.75] =	38.25
4) Topography Unit K reading:	38.75
USE LOWEST MOST RELIABLE VALUE	

Fig 1.—Example.

within the central 3 mm zone of the cornea, yielding a much more reliable measurement than the four point measured with the manual or automated keratometer. One should avoid the standard measurements from the manual or automated keratometers, because they are usually measuring near the edge of the optical zone where the cornea is changing dramatically. The keratometric samples are insufficient to give reliable values and can lead to significant refractive surprises.

It is also known that the cornea will undergo changes following the cataract procedure similar to those experienced after the initial RK; that is, a hyperopic shift on the first day after surgery with a gradual decrease of a few days to weeks.² One should not be concerned with 2 to 3 diopters of hyperopia, the first few days after the cataract surgery. **Do not perform a lens exchange; wait a few days and the hyperopia will subside.** It is also very important that a third generation formula be used in these cases, as with any unusual eye, such as the Holladay, SRK/T, Olsen, or Hoffer Q since older formulas such as the SRK I, SRK II, and Binkhorst can make significant unnecessary errors.³

Jack Holladay, MD
Houston, TX

A • Intraocular lens power calculation in
• eyes that have had radial keratotomy
• (RK) is a problem because of the inaccuracy of measuring the corneal power.

There are four ways to estimate the corneal power of the eye that has had refractive surgery:

1. Manual or automated office keratometry.
2. Refractive history method.
3. Contact lens method.
4. Corneal topography unit keratometry.

1. It is possible to use standard office *keratometers* to arrive at an accurate estimate of central corneal power. The problem is that you cannot tell in advance which eyes this method will be accurate in and which ones will be way off.

2. The *refractive history*⁴ requires the surgeon to obtain the average K reading of the eye prior to RK and from that value, subtract the spherical equiva-

lent change in refractive error (myopia) the eye obtained from the procedure, corrected by vertex distance to the plane of the cornea. Without a vertexometer, this can be calculated with the following formula:

$$R_c = R_s \div (1 - vR_s)$$

where $R_c = R_x$ at corneal plane;
 $R_s = R_x$ at vertex v , $V =$ vertex (in meters)

OR

$$R_c = R_s \div (1 - 0.012R_s)$$

assuming a vertex distance of 12 mm.

Therefore the surgeon must obtain:

- a) Pre-op RK Average
K reading 43.50 D
- b) Pre-RK Rx (SE) -4.00 @ vertex 12 mm =
-3.80 @ vertex 0 mm
- c) Post-RK Rx (SE) -0.50 @ vertex 12 mm =
-0.50 @ vertex 0 mm

The change in refractive error is calculated by algebraically subtracting the post-op power from the pre-op power (e.g., $-3.80 - [-0.50] = -3.30$ D).

The corneal power estimate is obtained by algebraically adding the change in refraction at the cornea to the pre-RK corneal power; e.g., $43.50 + (-3.30) = 40.20$ D. You would use 40.20 D as the corneal power for the IOL power calculation. It must be kept in mind that the later the post RK K readings and refractions are the better, but if the refraction is done when the cataract has begun to change the refractive error, this will create an error. So, caution is advised in verifying the accuracy of this data.

3. The third way to obtain the corneal power is the *contact lens method*.⁴ This can be done by first determining the refraction of the RK eye (e.g., -0.50 D (SE)) and then placing a plano hard contact lens of known base curve (e.g., 40.50 D) on the eye and performing a manifest refraction over the contact lens. If the refraction does not change (remains -0.50 D (SE)), the corneal curvature (K reading) is *equal* to the base curve of the contact lens (i.e., 40.50